HYDROPONIC GREENHOUSES PROJECT

NATURAL AND ARTIFICIAL FERTILIZERS: ORGANIC VS CHEMICAL

DELMAR HOLDING S.P.A
1. Is there a difference between organic and chemical fertilizers?

The reasons for using organic fertilizers are well known: the longer land is cultivated, the more the soil becomes depleted of the nutritional substances that plants utilize to maintain healthy growth, and organic substances replenish this soil. Chemical fertilizers, on the other hand, help the plant grow. But, then the question remains whether there is a true difference between these types of fertilizers.

According to popular belief, there is a difference: the term ‘organic’ is usually associated with the idea of natural nutrition for plants and soil, while ‘chemical’ is associated with artificial nutrition. However, for most people who work in this field, there is little difference between the two.

In reality, these terms are ‘sub products’ of fertilizers. That is, when we replenish the nutrition of plants, we are providing them with different types of fertilizers, both organic and chemical.

The most accurate definition of ‘fertilizers’ is the following: “any substance that contains nutritional elements or possesses physical characteristics, whether they be organic or inorganic (also known as chemical), that increases the fertility of the soil and provides adequate sustenance for plants.”

We can view fertilizers as ‘tools’ used in agriculture or gardening that allow for the creation, conservation, reconstitution, or increase of soil fertility.

Based on the type of improvement desired for the soil quality, fertilizers are divided in three categories:

1. **Organic**: enrich the soil with one or more nutritional elements absorbed by plants;
2. **Amendments**: any organic or inorganic substance that can provide the plant with the elements necessary for growth;
3. **Corrective**: as the name implies, these are any substance that is capable of modifying or improving the chemical composition of soil. For example, they are used to change the pH of soil to desired levels.

These elements provide small alterations that may bring enormous changes. This can be seen when choosing the composition of fertilizers. If, for example, the goal is to focus on growing the plant rather than promoting flowering, the fertilizer composition will be adapted to those needs.

Taking advantage of the types of fertilizers works in the same way. If the goal is to correct the pH of soil, a corrective fertilizer can be added. On the other hand, if the goal is to concentrate on flower growth, we can rely on amendments to improve the soil texture and chemical structure to promote this result. Consequently, fertilizers allow for the possibility to directly impact specific qualities of plants, rather than simply replenishing nutritional requirements.
1.1 The first fertilizers recorded in history

The first chemical fertilizer was “calcium superphosphate”, patented by the English scientist Sir John Bennet Lawes (1814-1900) in 1842. As a chemist and agronomist, he founded the Rothamsted agricultural station, where he conducted large-scale research on plant nutrition and different fertilizer compositions for cultivating plants.

2. Types of fertilizers

The most essential requirements for plants are water and sunlight. Then there are the nutritional requirements:

- **Macronutrients**: Nitrogen (N), Phosphorous (P), Potassium (K), and Calcium (Ca);
- **Micronutrients**: Iron, Copper, Manganese, Zinc, and Sulphur, which plants assimilate from the soil.

Once these substances are assimilated from the soil, the soil becomes depleted of them, so this is where fertilizers come into play. **The objective is to replenish the original fertility of the soil.** The more intense the cultivation of that soil, the more intense the fertilization activities will have to be.

Fertilizers are generally divided in “organic fertilizers” and “chemical fertilizers”, or rather natural or mineral fertilizers.

3. Organic (natural) fertilizers

These types of fertilizers are plant and animal by-products, and besides their capacity to fertilize soil (via nitrogen, phosphorous, and potassium), they contain carbon. Generally speaking, organic fertilizers originate from compost, manure, or animal remains. Below is a brief description of the major organic fertilizers.

3.1 Manures

This is generally derived from equine or bovine digestion by-products. It is an excellent natural fertilizer due to its nutritive properties for both cultivation and gardening. Manure is then transformed into fertilizers following three steps: in the first phase, the manure is left to mature for **up to six months**; in the second phase, it is left to dry, and in the third phase is granulated and packaged for use.

Manure is generally sold in large bags and can be purchased from nurseries or agricultural wholesalers. It can be used alone or in mixture with other substances.
3.2 Chicken manure

As the term implies, it is chicken excrement. Even this type of manure requires a process of transformation, where the chicken excrement is left to mature, or ferment, then dried and granulated.

3.3 Leonardite

This fertilizer is derived from fossils, and is also used for organic farming since it does not contain chemical substances. It improves soil quality; it improves absorption capacity of nutritional elements and micronutrients, has invigorating and growth-stimulating properties for plants, and stimulates seed germination and root formation.

3.4 Blood meal

It is derived from bovine blood and is a fertilizer with high-nitrogen content. It is excellent for vegetable gardens and acidophilic plants, but since it is derived directly from animals, it requires appropriate transformation process and should be used with caution. It can be found in either powder or liquid form.

3.5 Hoof and horn

As the term indicates, it is derived from hooves and horns of animals. This type of fertilizer contains high levels of nitrogen that is beneficial to gardens, grass, and evergreens.

IT IS IMPORTANT TO NOTE THAT FOR ALL ORGANIC FERTILIZERS, THERE ARE LAWS LIMITING THE USE DUE TO THE PRESENCE OF HEAVY METALS, SUCH AS COPPER, ZINC, CHROME, AND LEAD.
4. Chemical (inorganic) fertilizers

Chemical, or inorganic, fertilizers are those produced industrially and are nutritionally balanced by mixing macro and micronutrients in proportions based on desired plant requirements.

There are various types of chemical fertilizers, such as:

- **nitrogen-rich**, that promotes stem and leaf growth, and is suitable for evergreens and grasses;
- **phosphorous-rich**, that stimulate root growth and is thus suitable for plant early growth. It is indicated mostly for flowering plants;
- **potassium-rich**, that stimulates flower and fruit growth, and the formation of the lignifying protective layer of stems.

Chemical fertilizers can be simple or complex depending on the number of elements present in them. The quantity displayed in in percentage of the macro and micronutrients is what determines the name of the type of fertilizer.

The percentages of the various elements are indicated on the label of the fertilizer’s container.

The first number indicates the percentage of nitrogen, the second indicates the percentage of phosphorous, and so on.

Among the most recent synthetic fertilizers, the complex mixture of elements may result in some being chemically bound together, thus creating a unique and innovative product, not just a simple mixture of macro and micronutrients.

4.1 Chemical fertilizers, their popularity, dangers, and harms

The advent of using modern chemistry in agriculture has definitely created a permanent impact and change. Here we answer a few questions that commonly arise, such as: what effects may chemical fertilizers have had on agriculture? What advantages and harms have resulted? And most importantly, at what price?
4.1.1 Popularity growth of 500%

Use of chemical fertilizers has never been as high as it has been in the past few decades. In the last 50 years alone, their production and use have quintupled. According to data from the United Nation’s Food and Agricultural Organization (FAO), from 2005 to 2012 the yearly world use has increased from 120 Kg/hectar to 140 Kg/hectar.

China alone consumes 344 Kg/hectar in a year, followed by Brazil and Japan. On the other hand there are countries where fertilization consumption remains very low. In Ghana, for example, they use 7.5 Kg/hectar/year. Many countries on the African Continent also scarcely use fertilizers, thus making it an interesting land for fertilizer use.

4.2 What are chemical fertilizers made of?

Chemical fertilizers are obtained from extractions or form physical and/or chemical processes. They are classified based on both the type of nutritional elements and the actual nutritional contents within the fertilizer.

Types of nutritional elements:

- **Principal nutritional elements**: nitrogen, phosphorous, potassium (essential for the growth of plants that use these elements in large quantities);
- **Secondary nutritional elements**: calcium, magnesium, sodium, and sulphur (important for general plant growth and are consumed by them in medium quantities);
- **Micronutrients**: boron, cobalt, copper, iron, manganese, molybdenum, zinc (important for plant growth and are consumed in small quantities)

Nutritional contents:

- **Simple fertilizers**: contains only one main nutritional element, such as nitrogen, phosphate, or potassium;
- **Mixed fertilizers**: contains at least two main nutritional elements obtained via mixing or chemical processes.

The “title” of a fertilizer is derived from the elemental content of the substance, and it is expressed based on the mass percentage.
4.3 Interesting facts

74% of fertilizers are mostly made of nitrogen, and in some this rises to 90%. Nitrogen is by far the most used fertilizing element. Below, is also a list of the most common nitrogen-based fertilizers:

- Ammonium sulfate
- Ammonium chloride
- Ammonium nitrate
- Calcium nitrate
- Sodium nitrate
- Urea
- Calcium cyanamide

Almost all of these fertilizers contain ammonia, which is synthesized from the combination of gaseous nitrogen with high-temperature hydrogen, reaching about 500°C and high pressure of about 300 atm.

For some mixtures, relatively ‘impure’ ammonia can also be used and obtained from a byproduct of the gases released when transforming cast iron or steel.

Consequently, this type of activity may have a large and harmful environmental impact. Worldwide this chemical agent made of one nitrogen and three hydrogens (NH₃) is underestimated. Ammonia is the precursor of modern nitrogen-based fertilizers that are used in agriculture around the world. But, with the amount of nitrogen in the soil, agronomists have had tremendous increase in production.

Much gratitude must be given to Frits Haber and Carl Bosch, the scientists who first synthesized ammonia in 1909. This is partly because about 40% of our daily intake of vegetable protein is thanks to their discovery. (source: Vaclav Smil from the University of Manitoba).
Today, about 87 million tons on nitrogen-based fertilizers are produced annually according to the International Fertilizer Industry Association (IFA). Such high numbers may stimulate incentives to explore new technologies to reduce the environmental burden and reduce energy consumption of these substances.

As an example, the cost of phosphatic rocks from which fertilizers are extracted has risen from 50 to $400/ton from 2012 to 2013.

Chemical fertilizers thus have serious impacts. First of all, producing chemical fertilizers consumes a lot of energy. Producing one ton of ammonia requires the equivalent of one ton of natural gas. This process also has a huge impact on CO₂ emissions, packaging waste, transportation, and distribution from the few origins to the multitude of destinations worldwide. It is known as one of the most environmentally harmful production and distribution activities around the globe.

### 4.4 What are the uses for chemical fertilizers?

The world’s agriculture requires chemical fertilizers because the population is in continuous growth and thus a greater production is necessary to maintain it. It is important to note, however, that chemical fertilizers shouldn’t substitute organic fertilizers; they should be integrated with them.

Besides the benefit of energy cost reduction and reducing environmental impact, it is also a matter if ‘smart economy.’ Chemical fertilizers such as those derived from fossils are limited resources on which agriculture is presently very dependent.
4.5 The harm of improper use of chemical fertilizers

In the last fifty years, agricultural production has continued to grow. The results have been surprising and especially devastating for the environment.

The resources for producing fertilizers are also decreasing, for example:

- **Potassium** extracted from specific types of rocks are progressively being used up;
- **Phosphorous** is an interesting example because **80% of it extracted worldwide is used for making fertilizers**, but plants absorb less than 20% of the amount given. The rest of the phosphorous gets washed away, ends up in sewers, or remains in the soil.

The effects of using fertilizers incorrectly has both direct and indirect effects. The most apparent one is **the effect seen in aquifers, where nitrates and herbicides, animal growth hormones, and health effects on farm animals.**

There are also the **indirect effects**, such as **abandonment of mountain-area agriculture, concentration of agriculture in few consolidated areas, and increase in energy costs of transportation.**

There are also the environmental problems due to **eutrophication of water**, where the nutritional content in these environments increase causing algae to proliferate and consequently reduce the oxygen in water leading to harms of marine life (see photos below). We also already mentioned the **environmental impact** these fertilizers have on **aquifers** as well as the **devastating effects over-cultivation has on soil in general.**
5. Conclusion and reasoning for types of fertilizers chosen in the “Hydroponic Greenhouse Project”

Based on the information provided thus far, it can be concluded that there are two main types of fertilizers: organic and chemical.

It is commonly perceived that “chemical” fertilizers are artificially synthesized. Synthetic kinds directly penetrate the plants though osmosis by taking advantage of the differences in concentration between soil and roots. This generally results in a faster growth of the plant, and consequently greater productivity of crops per hectare. However, chemical fertilizers may not contain all the mineral substances naturally present in soil. An example of this is selenium, which was found to be missing in some cereals cultivated with fertilizers that were ‘incomplete’ due to this micronutrient. It is for reasons like these that fertilizers should be formulated specifically and nutritionally balanced. An uncontrolled use of fertilizers, along with use of herbicides and pesticides, may cause and alteration in the soil that could lead to excess nitrogen being absorbed by plants and ultimately affecting even humans’ health.

Organic fertilizers are by definition originating from vegetable or animal sources. Usually, if utilized correctly, they contain the complete nutritional substances required for microorganisms within the soil to directly provide the minerals necessary for healthy crop growth.

It is important to note that organic fertilizers are not always the “best” ones since even the uncontrolled use of manure may cause environmental damage due to its high content of nitrogen released into the soil. In fact, when fertilizer is applied to soil, the nitrogen distributed originates from different sources: organic (compost, manure, and organic and mineral fertilizers), ureic (urea and a few mixed fertilizers), ammonia-based (ammonium sulfate, ammonium nitrate, and some mixed fertilizers), or nitric (calcium nitrate, ammonium nitrate, and some mixed fertilizers).

Organic nitrogen transforms rather slowly into ammonium nitrate, and thus nitrate. The same happens with urea nitrate a little more rapidly, and even more rapidly with ammonium nitrate. Since the transformation rate depends greatly on the microorganism activity present in soil, environmental conditions like warmer temperatures and humidity favor this increased rate of transformation. Generally, these transformations then become more rapid in spring and summer, and are slowed during winter and dry conditions. At the end of all these processes, however, there is always the formation of nitrate, which is absorbed by all plants and what is not absorbed is washed away penetrating the soil via “leaching.” The excess nitrates may cause serious environmental damage by impoverishing soil, polluting aquifers, and causing the previously mentioned eutrophication of water.
The water that seeps deep into the soil can reach aquifers, contaminating them with excessive amounts of nutrients, making these water sources non-potable. If these water sources come up to the surface, they can also mix into and contaminate lakes, rivers, lagoons, and even the oceans. Nitrogen gets absorbed by algae and promotes rapid growth, the consequent increase in algae size and quantity creates shade for the marine life that is dependent on light, and creates an alteration in the delicate ecosystem. This is called “eutrophication of water” which derives from the Latin term ‘good nutrition,’ and describes the exaggerated nutritional content of water that has devastating environmental impacts.

It is important to remember though that the most harmful consequences of chemical fertilizers are the indirect ones associated with the high-energy costs of production and transportation, and the consequent carbon dioxide emissions in our environment.

Understanding all the different types of fertilizers can lead people embrace organic and biodynamic food sources that are not only good for health, but also good for the entire ecosystem. If the common addition of pesticides and herbicides (which are actual poisons absorbed by plants and soil) is considered, then one can only imagine the quality of the food we eat.

It is for all these reasons that Delmar Holding is dedicated to using the most innovative cultivation technologies, both in the soil and out, to guarantee the correct balance of nutrients for plants and soil via the use of high-quality, low nitrogen, and premium quality fertilizers.

More specifically, our soil-based agriculture adjacent to our hydroponic greenhouses will only be fertilized with natural, high-quality nutrients so that the soil quality will not be affected.

With regards to our hydroponics, we will only use water-soluble mineral fertilizers that are complete, nutritive, and rapidly absorbed by the roots throughout the life of the plant. The use of nitrogen will be below 10-15% and the pH will remain a healthy constant so that there are no nutritional imbalances due to calcium deficiencies. Within the greenhouses the cultivation will be done in a manner that is environmentally “clean” and perfectly assimilated to organic farming in fields, without the use of pesticides, herbicides, or any other harmful additive.

We at Delmar Holding believe that faced with an ever-growing global population, we have an obligation to face a new era for the use of “sustainable” fertilizers capable of combining technical innovation to increase production with protection of the environment and a “return to the origins” to guarantee a more natural process.

This is Delmar Holding’s true challenge: progress in the future utilizing the most innovative technologies while still keeping an “eye on the past” in order to maintain products healthy like they used to be.
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